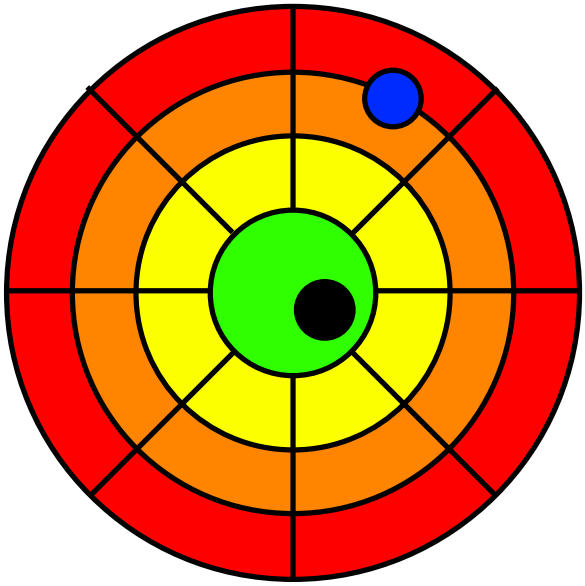
PB-3 Propeller Balancer

User Manual

Smart Avionics Ltd.



PB-3 Propeller Balancer: User Manual

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Chapter 1. Introduction

This manual describes the Smart Avionics PB-3 product and how it is used in a propeller balancing system.

The PB-3 is marked with this warning symbol to indicate that it emits bright light (optical radiation).

When the PB-3 is active, it emits infrared light from the red panel in a narrow, concentrated beam. This invisible light could irritate or otherwise damage the human eye if viewed at close range.

Do not look directly into the red panel when the PB-3 is on.

1.1. Balancing System Overview

The propeller balancing system has these main components:

Accelerometer	This is mounted on the front of the engine to detect the vibration due to propeller imbalance.
Optical tachometer	A strip of reflective tape is attached to one propeller blade and an optical sensor detects the tape as it passes and generates the tachometer signal required by the balancer.
Signal processor	This digitises the vibration signal and sends the resulting data to an Android device using Bluetooth® wireless communications.
Android™ device	This provides the user interface as described in the Propeller Balancer App User Manual.

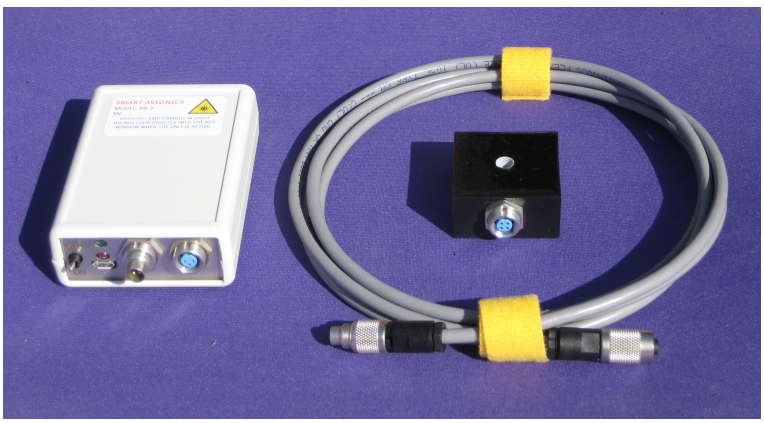

Fig 1.1. PB-3 Hardware

The PB-3 combines the optical tachometer and the signal processor into one lightweight unit. Typically, the PB-3 is attached to the outside of the aircraft's

engine cowling such that the optical sensor can “see” the reflective tape on the propeller blade through the red panel.

Optionally, the PB-3 can use an externally generated tachometer signal that provides one pulse per revolution.

1.2. PB-3 Rear Panel

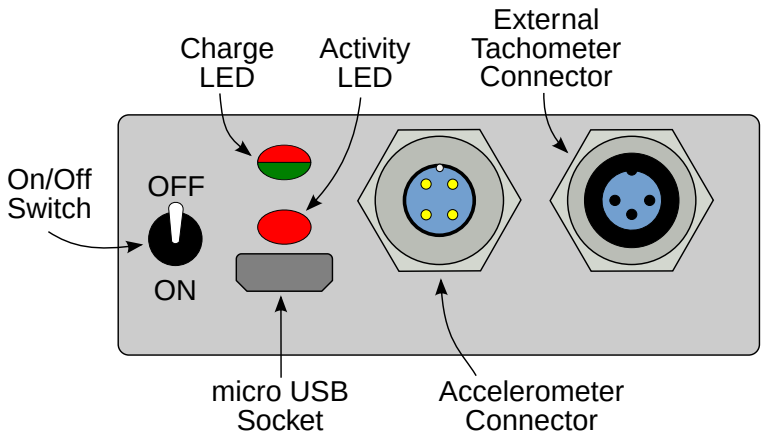

Fig 1.2. PB-3 Rear Panel

The rear panel contains:

On/Off switch This functions in the obvious manner but note that to save battery power, the PB-3 will turn itself off after 30 minutes of inactivity. If that happens, to turn the PB-3 on again, simply return the switch to the OFF position and then back to the ON position.

Charge LED Illuminated when the PB-3 is being charged:

Green (continuous)	Battery is charging.
Green (flashing)	Battery is fully charged – disconnect the charger.
Red (continuous)	Fault indication – disconnect the charger and contact Smart Avionics for advice.
Red (flashing)	Battery temperature is outside the allowed range for charging.

Activity LED A red LED that indicates PB-3 activity:

Off	Unit is off.
One flash every 2 seconds	Unit is on but not currently connected to an Android device.

Two flashes every 2 seconds	Unit is connected to an Android device.
	When the tachometer is active, the LED function will be inverted (mostly on instead of mostly off).
Micro USB socket	Used for charging the PB-3 and upgrading the device's firmware.
Accelerometer connector	Connects to the accelerometer mounted on the engine.
External tachometer connector	Connects to an (optional) external tachometer. An external tachometer must be used for gyroplane rotor balancing.

1.3. Battery Charging

The PB-3's battery is charged via the micro USB socket located on the rear panel. Any 5V charger fitted with a micro USB-B plug that can supply a minimum of 450mA may be used to charge the PB-3 (e.g. most modern mobile phone chargers). The PB-3 itself limits the charge current so the maximum current supplied by the charger is irrelevant.

The PB-3 can also be charged by connecting it directly to a computer's USB port using a cable that has a USB-A plug at one end and a micro USB-B plug at the other end. Do not connect the PB-3 to an unpowered hub.

When the power source is connected, the PB-3's charge LED will be continuously green while the battery is charging and will flash green when the battery becomes fully charged.

When the battery is fully charged, disconnect the PB-3 from the power source. It takes approximately 2.5 hours to recharge a completely flat battery.

Note

The PB-3 may be switched on while charging but if you leave it switched on, it will increase the time taken to charge the battery and also it may stop the charge LED from flashing when the battery has become fully charged.

Important

Only charge the battery when the ambient temperature is greater than 0°C (32°F) and less than 40°C (104°F) – if the PB-3's internal temperature is outside of this range, the charge LED will flash red.

Make sure the PB-3 is not exposed to direct sunlight while it is being charged as this could cause the upper temperature limit to be exceeded.

If you are not going to use the PB-3 for some time (months), it is best to store it with the battery approximately 50% charged.

1.4. Replacing the Battery

The PB-3 is powered by a single 3.7V 800mAh Lithium Ion battery of type Samsung AB463446BU. To replace the battery follow these steps:

1. Disconnect all cables from the PB-3 and ensure it is switched off.

2. Remove the 4 visible screws on the base of the unit and remove the top cover. The battery is contained within a plastic holder that is attached to the top circuit board. The holder incorporates a flexible tab that clips onto the base of the battery to keep it in place.

3. Grip either side of the base of the battery and gently lift the flexible tab sufficiently so that the battery can be removed by pulling it away from the 3 pronged connector. To avoid damaging the flexible tab, take care not to lift the tab too far (no more than 5mm) and keep the battery parallel to the circuit board as it is being removed.

4. To install the new battery, gently lift the tab a little so you can insert the battery and push the battery forward to locate the 3 prongs of the connector into the 3 recesses on the top end of the battery. You may need to wiggle the battery slightly from side to side to allow the prongs to make contact. Push the battery as far forward as it will go. It should then be possible to press the end of the plastic tab down so that it grips the base of the battery.

5. Check that the battery is correctly installed by momentarily switching the PB-3 on and verifying that the LED flashes as normal. If necessary, adjust the position of the battery by raising the flexible tab, withdrawing the battery 1 cm or so, and then pushing it home again taking care to ensure that the prongs of the battery connector go into the recesses on the top of the battery.

6. Replace the top cover noting that the shallow cutouts in one of the flanges should be at the rear end of the PB-3 to clear the connectors. Replace the 4 screws which should be screwed fully home but not overtightened.

7. The old battery must be disposed of according to local regulations. Do not dispose of it in the household waste and do not damage it in any way.

Chapter 2. Preparing for Propeller Balancing

Caution

Propellers can kill.

Make sure that the ignition is switched off before touching the propeller.

Always assume that the engine could fire when the propeller is being moved.

Make sure that the aircraft is securely chocked or tied down while carrying out the balancing process.

2.1. Additional Items Required

To carry out the balancing process, you will need the following items in addition to the balancer kit:

- Balance weights (typically AN970 washers) and a means of securely attaching them to the spinner backplate.

  A scale for measuring the weights is useful but not absolutely essential as the balancer works in terms of relative weight rather than absolute weight.

- If necessary, a bracket for mounting the accelerometer onto the front of the engine (optional, depending on engine type and installation details). An M6 screw and washer are supplied which can be used to attach the accelerometer to the back of a Rotax 4-stroke gearbox if the vacuum pump option is not fitted.

- A roll of 25mm wide masking tape.

2.2. Positioning the Aircraft

The following points should be observed regarding positioning the aircraft for a propeller balancing session:

1. The position must be safe for ground running of the engine. Typically, the engine will need to be run at cruise RPM and the aircraft should be braked and chocked and, if necessary, tied down.

2. When deciding where to locate the PB-3, the position of the aircraft should be such that direct sunlight will not fall onto the PB-3's red window. If the

sun is low on the horizon it is best if the sun does not fall within the arc of the propeller when viewed from the location of the PB-3.

3. If the wind is appreciable (> 5kts), point the aircraft as close into wind as possible while observing point 2 above.

2.3. Mounting the Accelerometer

Remove sufficient cowlings to gain access to the front of the engine. Mount the accelerometer (40mm square with a 6mm hole through the middle) as near to the front of the engine as possible with the accelerometer's sensing axis pointing directly at the propeller's centre line.

- For single axis sensors, the accelerometer's X axis coincides with the direction of the sensor's cable socket.
- For dual axis sensors, the accelerometer's X axis coincides with the direction of the sensor's cable socket and its Y axis is at 90° to the direction of the cable socket.

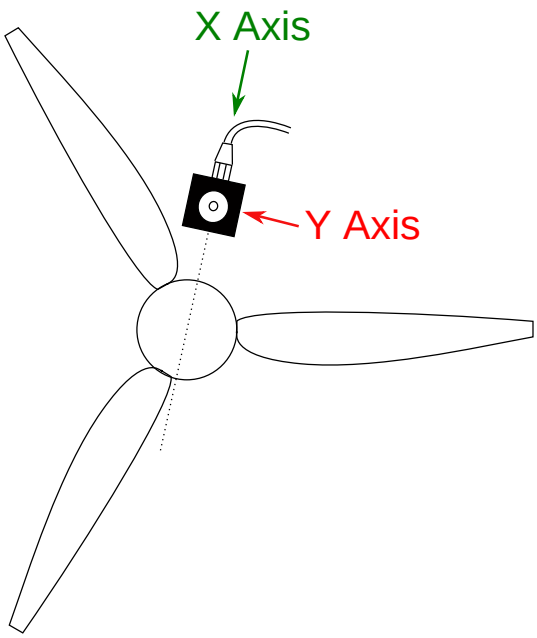

Fig 2.1. Accelerometer Axes and Orientation

Important

The sensing axis used must intersect the axis of rotation of the propeller.

If you have a dual axis sensor, remember to configure the Android App to use the correct axis.

Note that the accelerometer does not have to be directly above the propeller's axis of rotation. However, to get the best results you should not mount the accelerometer such that the sensing axis is parallel with the engine's cylinders.

On a Rotax 4-stroke engine that doesn't have a vacuum pump attached, the best place to mount the accelerometer is on the rear of the gearbox using one of the available tapped holes and the supplied M6 screw and washer.

Fig 2.2. Accelerometer Mounted on a Rotax 912 Gearbox

If the accelerometer cannot be bolted directly to the engine, some form of bracket will be required. Obviously, the details of this are engine specific but it could be as simple as a strip of metal with a hole drilled at each end. If a bracket is used, it must be sufficiently stiff to ensure that the accelerometer does not move with respect to the engine.

However the accelerometer is mounted, it must not be subjected to excessive temperatures. The temperature of the sensor should not exceed 85° C. If necessary, thermally insulating material can be sandwiched between the accelerometer and the engine (or bracket) to reduce the amount of heat conducted to the accelerometer. If the surrounding area will be very hot, the accelerometer could be wrapped in thermally insulating material (once the cable has been attached).

Important

The accelerometer is robust but may be damaged if dropped on a hard surface.

It is preferable to refit the engine cowling to minimise the turbulence generated by the airflow from the propeller. For some aircraft, the cowling will have to be refitted to provide a suitable mounting position for the optical sensor.

However, if the balance weights are to be added to the rear of the spinner backplate, it may pay to leave the cowling off (if possible) during the balancing process so that it is easier to gain access to the weights. Once the balancing has been completed, the cowling could be replaced and a final reading taken to determine the level of vibration achieved.

2.4. Mounting the PB-3

Owing to the variation in aircraft cowling shapes and sizes, only generic instructions can be provided here. You may find that a little experimentation is required to obtain the best results. A rectangle of flexible plastic is supplied that attaches to the PB-3 using Velcro™ tape. This rectangle is first taped to the outside of the cowling using masking tape and the PB-3 is then firmly pressed against it.

Caution

This method of mounting the PB-3 on the cowling is perfectly adequate when the aircraft is stationary on the ground. **Under no circumstances should the aircraft be flown with the PB-3 attached in this way.**

Caution

If the propeller is a pusher, i.e. the cowling is in front of the propeller rather than behind, extra care should be taken to ensure that the PB-3 cannot become detached from the cowling and hit the propeller blades. As a minimum, tape the accelerometer cable to the cowling so that it will restrain the PB-3 in the event of it becoming detached from the cowling. If you have any doubt as to the security of the PB-3, don't risk destroying it and the propeller.

Position the PB-3 such that the red panel is pointing towards the propeller. If the PB-3's orientation is correct, the blades will sweep across the width of the red panel as the propeller rotates. The distance from the front of the sensor to the propeller should be in the range 15-25cm.

Fig 2.3. PB-3 on a Europa Cowling

Fig 2.3 shows the PB-3 mounted on the side of a Europa classic cowling. Notice how it is angled slightly up to ensure that the angle of the infrared beam relative to the rear surface of the propeller is approximately 30°.

Important

To detect the propeller RPM reliably, the PB-3 must be positioned such that the angle of the infrared beam relative to the face of the propeller blade is approximately 30° from the normal (either in front of or behind the normal). Fig 2.4 illustrates this.

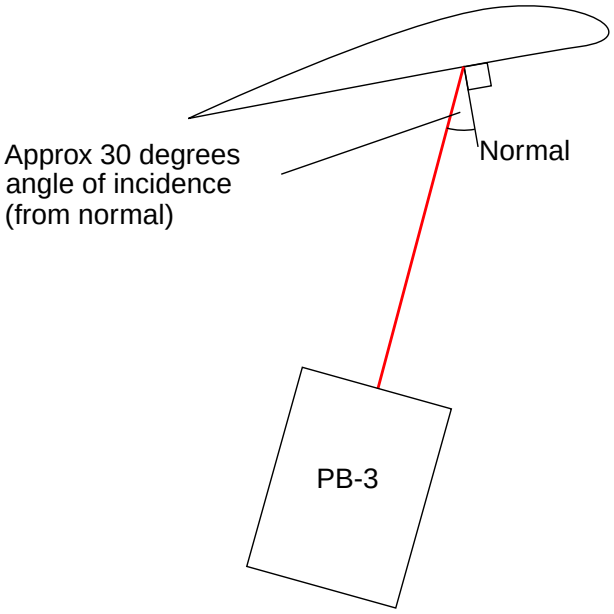

Fig 2.4. PB-3 Angle of Incidence

If the angle is too small, the PB-3 will tend to detect the other blades (especially if they are highly reflective) and the RPM will appear erratically too high. If the angle is too large, the blade with the reflective tape will not be reliably detected and the RPM will appear zero or erratically too low.

2.5. Attaching the Reflective Tape

With the engine ignition switched off, rotate the propeller so that one blade lies directly on the sensing axis of the PB-3, i.e. if you could see through the blade you would be looking directly into the sensor's red panel. Make sure that the area on the back of the blade where the tape is going to be attached is clean. Apply a strip of 25mm wide masking tape to the back of the propeller at the point that the infrared beam will hit the blade. Wrap the tape a short distance around the leading edge of the blade but don't wrap it around the trailing edge.

Important

The tape must be oriented such that it is parallel to the PB-3's red panel. This may mean that the tape is not at 90° to the leading edge of the blade but that doesn't matter. The important point is that the tape is parallel with the red panel.

Now put a strip of the reflective tape on top of the masking tape. Again, wrap the tape a little way around the leading edge of the propeller to stop it peeling back. The purpose of the masking tape is simply to make it easy to remove the (very thin) reflecting tape when the job is done.

Fig 2.5 shows the PB-3 mounted on the side of a Europa classic cowling and the reflective tape attached to the rear face of a propeller blade.

Fig 2.5. PB-3 and Reflective Tape

If you subsequently find that the optical tachometer cannot reliably detect the RPM, verify that the tape really is in the correct position. You may find that adding another strip of reflective tape next to the first strip will improve the situation.

Note

The Bluetooth radio signal cannot pass through metal so if the PB-3 is mounted on a metal cowling, you should not expect it to be able to communicate with the Android device when the cowling is between the two units.

In practice, that means that it is unlikely you will be able to operate the balancer from within a metal aircraft's cockpit. It will work when you are positioned such that the radio signals can reach you without passing through the aircraft's structure (i.e. you are standing on the side of the aircraft that the PB-3 is attached to).

2.6. Attaching the Cable

Connect the accelerometer to the PB-3 using the supplied cable and make sure the connectors' retaining collars are screwed down (take care to only rotate the metal retaining collar and not the plastic body of the connector).

Any slack in the cable should be taken up by coiling the cable and then applying a few strategically placed pieces of masking tape to stop the cable flapping around in the propeller breeze.

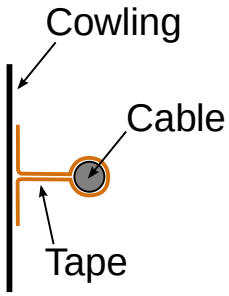

Fig 2.6. Cable Taping

If you tape the cable as shown in the above figure, it is unlikely to come adrift. Taping the cable securely provides an extra benefit in that, in the unlikely event of the PB-3 coming away from the cowling, the cable should stop it hitting the ground.

Important

To obtain the best results, the cable from the accelerometer should be kept away from sources of electrical interference such as ignition leads, magnetos/ignition units, generators/alternators/regulators and their associated wiring.

Be especially careful to ensure that the cable cannot get close to rotating components or very hot surfaces.

Chapter 3. Upgrading the PB-3's Firmware

The PB-3's firmware can be upgraded by connecting the PB-3 to a PC with a USB cable and then using a simple command line program, **lpc21isp**, to send the firmware to the PB-3. Ready to use versions of this program for both Linux and Windows™ systems are available on the Smart Avionics website.

The new balancer firmware will be named `pb3-`*`version`*`.hex`, where *`version`* is the firmware version number.

3.1. Upgrading Using a Linux System

If you are using a Linux system, follow these steps:

1. Download the new firmware file and the lpc21isp program from the Smart Avionics website and save them in a convenient directory.

2. Open a command shell and cd to the directory containing the saved files.

   The lpc21isp program is zipped into an archive, so extract it and (to make your life easier) rename (mv) the executable to **lpc21isp**.

3. When you connect the PB-3 to the PC using a USB cable it will appear as a new USB serial device. We need to access that device by name. Linux systems generally name the USB serial devices with names like `/dev/ttyUSB`*`x`* where *`x`* is a number.

   Before you plug the USB cable into the PB-3, execute the following command to list the names of any USB serial devices already present:

   ```
   ls /dev/ttyUSB*
   ```

   You will either see a list of names or, if no USB serial devices are presently connected to your system, **ls** will gripe because the wildcard (`*`) didn't match anything.

4. Plug the PB-3 into the USB cable, switch it on and list the USB serial devices again. You should now see the PB-3's serial device name added to the list.

5. To send the firmware to the PB-3 execute:

   ```
   ./lpc21isp -control pb3-version.hex /dev/ttyUSBx 115200 12000
   ```

   Where `pb3-`*`version`*`.hex` is the name of the file containing the new firmware and `/dev/ttyUSB`*`x`* is the name of the PB-3's serial device.

Note

Some systems may require you to be logged in as root to access the USB serial devices.

The lpc21isp program should display diagnostic output similar to the example shown below (the lines have been shortened to fit the page).

6. Once the download has finished, you can switch off the PB-3 and disconnect the USB cable.

3.1.1. Example lpc21isp output

```
lpc21isp version 1.74
File pb3.hex:
 loaded...
 converted to binary format...
 image size : 90640
Image size : 90640
Synchronizing (ESC to abort). OK
Read bootcode version: 1
4
Read part ID: LPC1758, 512 kiB ROM / 64 kiB SRAM (0x25013F37)
Will start programming at Sector 1 if possible, and conclude
with Sector 0 to ensure that checksum is written last.
Erasing sector 0 first, to invalidate checksum. OK
Sector 1: ..........................................
Sector 2: ..........................................
Sector 3: ..........................................
Sector 4: ..........................................
Sector 5: ..........................................
Sector 6: ..........................................
Sector 7: ..........................................
Sector 8: ..........................................
Sector 9: ..........................................
Sector 10: .........................................
Sector 11: .........................................
Sector 12: .........................................
Sector 13: .........................................
Sector 14: .........................................
Sector 15: .........................................
Sector 16: .........................................
Sector 0: ..........................................
Download Finished... taking 20 seconds
Now launching the brand new code
```

3.2. Upgrading Using a Windows System

If you are using a Windows™ system, follow these steps:

1. Windows computers must have the VCP (Virtual Comm Port) driver installed. The drivers can be downloaded from:

   `http://www.ftdichip.com/Drivers/VCP.htm`.

   Please follow the FTDI instructions to install the driver.

2. Download the new firmware and the lpc21isp program from the Smart Avionics website and save them in a convenient folder.

   The lpc21isp program is zipped into an archive, so extract it and (to make your life easier) rename the executable **lpc21isp.exe**.

3. Connect the PB-3 to the PC with the USB cable and switch the PB-3 on. Go to **My Computer > Manage > Device Manager > Ports (COM & LPT)** and it should show an entry like: `USB Serial Port (COM`*x*`)` where *x* is a number.

4. Open a Command Prompt window (**Start Menu > Programs > Accessories > Command Prompt**) and using the **cd** command go to the directory (folder) containing the downloaded PB-3 firmware and the lpc21isp program. Now execute the following command:

   `.\lpc21isp -control pb3-`*version*`.hex COM`*x*` 115200 12000`

   Where `pb3-`*version*`.hex` is the name of the file containing the new firmware and `COM`*x* is the name of the serial device corresponding to the PB-3.

   The lpc21isp program should display diagnostic output similar to that shown in Section 3.1.1.

5. Once the download has finished, you can switch off the PB-3 and disconnect the USB cable.

Appendix A. Software Licences

The PB-3 uses the following 3rd party software packages.

A.1. KISS FFT Library

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Appendix B. EMC Compliance

To ensure EMC compliance, please observe the following conditions when using the PB-3:

1. Do not use the PB-3 in close proximity to other electrical equipment capable of generating large amounts of electrical interference.

2. All electrical equipment in the aircraft that is not required for either safety reasons or to facilitate the running of the engine should be switched off while the PB-3 is being used.

3. As described in this manual, avoid routing the PB-3's cables near to sources of electrical interference (such as engine ignition components and cabling).

4. Only use cables approved by Smart Avionics for connecting the sensors to the PB-3.

Appendix C. CE Declaration of Conformity

We, **Smart Avionics Ltd. Chorlton Lane Farm, Chorlton, Malpas, Cheshire. SY14 7ES. United Kingdom**, declare, on our own responsibility, that the PB-3 conforms with the essential requirements of the R&TTE Council Directive 1999/5/EC.

Conformity is declared to the following harmonised standards:

EMC EN61326-1:2006 “Electrical equipment for measurement, control and laboratory use - EMC Requirements".

RF EN 300328 V1.7.1 (2006-2010) “Electromagnetic compatibility and Radio spectrum Matters (ERM); wideband transmission systems; Data transmission equipment operating in the 2.4 GHz ISM band and using wideband modulation techniques".

Safety IEC 61010-1:2010 (3rd edition) and EN 61010-1:2010 “Safety requirements for electrical equipment for measurement, control and laboratory use".

Equipment type: Battery powered portable test/measurement.

Environment: External/Workshop.

I, the undersigned, hereby declare that the PB-3 conforms to the above Directive.

Mark Burton
Director
Smart Avionics Ltd.

22 June 2012

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